Effects of hydrological restoration on litterfall in a riparian bottomland forest in central Ohio: Preliminary results

Christopher J. Anderson and William J. Mitsch

Olentangy River Wetland Research Park, The Ohio State University

Abstract

At the Olentangy Wetland Research Park in Columbus, Ohio a hardwood riparian forest (bottomland) was hydrologically restored in June 2000. At the north end of the bottomland, a series of holes were notched in a 2-m tall dike that had separated a 250-m section of the bottomland from the adjacent Olentangy River. This restoration has allowed regular surface flow to occur in this section of the bottomland for the first time in about 100 years. In the southern portion of the bottomland, no impediment has occurred between the river and the bottomland and only one notch was cut in the southern section of the forest to further increase river inflows. This scenario provides an opportunity to examine the initial effect of hydrological restoration on the productivity of a bottomland forest. Net aboveground primary productivity (NAPP) of the northern and southern sections of this bottomland are being compared to determine if productivity has been improved in the bottomland. Initial results from litter traps installed throughout the two sections indicate that leaf, reproductive parts (flowers, seeds, etc.) and woody material (small twigs, bark, etc.) flux were comparable between the two sections. For the months of June through October, mean total litterfall was 450 ± 6 g-dry wt m^{-2} for the north restored section and 467 ± 30 g m^{-2} for the south reference section.

Introduction

Riparian bottomland forests are ecosystems that are influenced by an adjacent river or stream. These forests are highly productive systems because of the regular influx of nutrients, material and energy from adjacent waterways (Mitsch and Gosselink, 2000). The effect that hydrology has on wetland riparian forest productivity has been the subject of several studies (Brown and Peterson, 1983, Taylor et al., 1990; Robertson et al., 2001) and most investigators have concluded that periodic flooding has an important and positive effect on the productivity of the ecosystem. According to the subsidy-stress concept, flooding can be beneficial or detrimental to ecosystem productivity, depending upon the frequency, timing and duration of the flood event (Odum et al., 1979). This has been shown on the Danube River where Tockner et al. (2000) identified that floodplains have the highest productivity when their connection with the river alternates between a 'disconnection phase' (because of low river water levels) and a 'seepage/downstream surface connection phase' where low energy inflows of water occur. The benefit of this scenario is that the floodplain receives nutrient subsidies from the river, but water levels fall again before long-term anoxic conditions occur that could potentially stress the forest.

In a recent study of riparian forests along the Olentangy River, Cochran (2001) evaluated three bottomland forests, including the Olentangy River wetland Research Park bottomland forest, between 1998 and 2000 (prior to the restoration of the northern section). The study evaluated ecosystem productivity and basal growth of affected tree species. It was determined that the mean net aboveground primary productivity (NAPP) of the hydrologically restricted ORW bottomland was 800 g $m^{-2} yr^{-1}$ compared to other open bottomlands on the river that produced a mean NAPP of 1280 g $m^{-2} yr^{-1}$. The higher productivity in these bottomland forests was attributed to their ability to receive river influx. These values can also be compared to other studies in the eastern United States. Megonigal et al. (1997) calculated NAPP to be 1,208 ± 198 g $m^{-2} yr^{-1}$ for hardwood bottomlands in South Carolina and Mitsch et al. found NAPP between 1,280 and 1,334 in bottomland forests in Kentucky (Mitsch et al., 1991).

A productivity study is currently being conducted on the ORW bottomland to evaluate the potential effect of the restoration effort on forest productivity. The goals of this study are to answer the following questions:

1) Has the reconnection of the Olentangy River and the northern section of the ORW bottomland forest increased forest productivity?

2) Has there been a significant increase in the average annual growth rate of wetland trees in the past three+ years since the bottomland has been restored?

3) Is there a difference in change of annual growth rate between different species?

We hypothesize that the newly established connection with the Olentangy River has resulted in increased productivity at the ecosystem and individual tree level. This hypothesis will be tested through measurements of net aboveground primary productivity (NAPP) at the northern section of the bottomland, and evaluation of basal growth of trees before and after the restoration. Specifically, we hypothesize that because of the hydrologic restoration, the NAPP of the northern section will be now comparable to that of the southern section. This report provides preliminary results of the litterfall productivity in the ORW bottomland from June through October 2004.

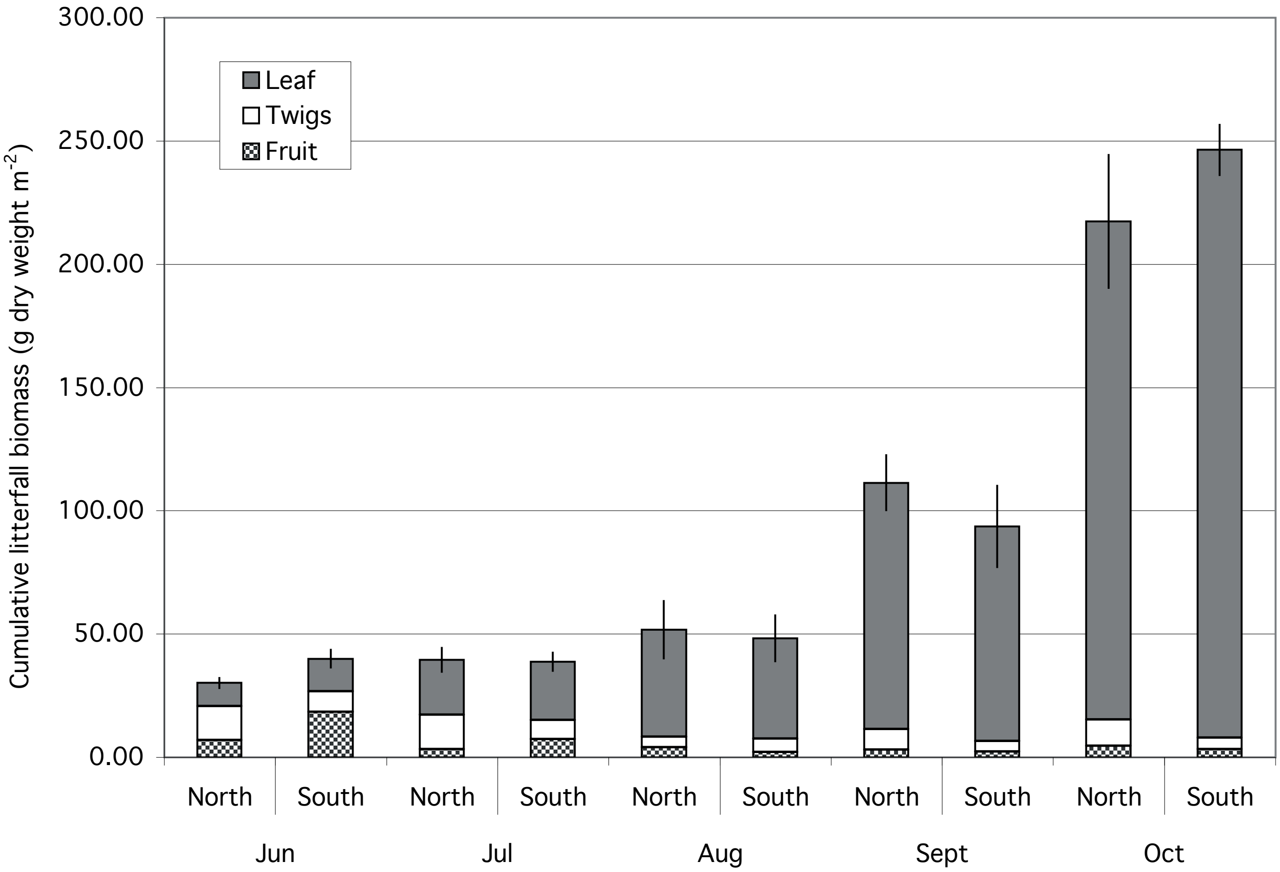

Figure 1. Cumulative litterfall biomass (g dry weight m^{-2}) for the north and south section of the ORW bottomland forest between June and October 2004. No significant differences were detected between the sections for any month.

Methods

In April 2003, a series of 10 plots (20 m x 25 m) were installed throughout the bottomland—four in the north section and six in the south section. North section plots were installed in the middle of the forest, perpendicular to the dike breaks where low elevations naturally occur. Southern section plots were evenly installed in low elevation areas where flooding has normally occurred.

A total of five 0.25 m^{-2} leaf litter traps were randomly installed into each plot in 2004. The traps are 15 cm tall wood frames with a 1-mm mesh screen along the bottom. To avoid floodwaters, the traps were installed on 0.75 m stilts using wooden lathe. From June through August 2004, litter from each plot was collected biweekly and in September and October 2004 it was collected weekly. After each collection, litter was returned to the laboratory, air-dried for one week and then dried at 105˚C in a drying oven for two days. Immediately after drying, litter was separated into leaves, reproductive parts (flowers, seed, etc.) and woody material (small twigs, bark, etc.) and weighed for each plot to the nearest 0.1 g.

T-tests were conducted to compare litterfall and its various components between the north and south sections of the forest using Microsoft Excel. For all analyses, $P<0.05$ was considered a significant difference and $P<0.01$ was considered a highly significant difference.

Results and discussion

As expected, litterfall steadily increased between June and October 2003 (Figure 1). No significant differences in litterfall were detected between the north and south sections during any of the months. Most litterfall was comprised of leaf material; however woody and reproductive material represented a substantial portion of the monthly totals in June and July. Higher than normal percentages of woody material in the north section were partially caused by a dead, mature tree just outside of one of the plots. Higher than normal reproductive material in the south section was likely caused by the greater number of mature tree specimens. Total litterfall was 450 ± 6 g m^{-2} for the north section and 467 ± 30 g m^{-2} for the south section for June - October 2004, a difference that was not significant ($p = 0.60$).

This is only a portion of the overall data that will be used to examine productivity. Collection of litterfall data will continue through May 2005 in order to determine an annual total. Although preliminary data suggest that litterfall will be comparable, early indications from the November 2004 data suggest greater litterfall in the south section. The other major component to be measured is the amount of woody growth (Newbould, 1978). Basal dimensions were measured in early April 2004 and will be re-measured in early 2005. These data, combined with litterfall results and NAPP estimates, will provide the means to compare the restoration and reference sections of the bottomland hardwood forest for the effects of the increased flooding on ecosystem function. the restoration and reference sections of the bottomland hardwood forest for the effects of the increased flooding on ecosystem function.

References

Brown S. and D.L. Peterson. 1983. Structural characteristics and biomass production of two Illinois bottomland forests. American Midland Naturalist 110:107-117.

Cochran, M. 2001. Effect of Hydrology on bottomland hardwood forest productivity in central Ohio (USA). M.S. Thesis. The Ohio State University, Columbus, OH, USA.

Megonigal, J.P., W.H. Conner, S. Kroeger and R.R. Sharitz. 1997. Aboveground production in southeastern floodplain forests: a test of the subsidy-stress hypothesis. Ecology 78:370-384.

Mitsch, W.J., J.R. Taylor and K.B. Benson. 1991. Estimating primary productivity of forested wetland communities in different hydrologic landscapes. Landscape Ecology 5:75-92.

Mitsch, W.J. and J.G. Gosselink. 2000. Wetlands, third edition. John Wiley & Sons, inc., New York, NY.

Newbould, J. 1978. Methods for estimating the primary production of forests. Blackwell, Oxford, England.

Odum, E.P., J.T. Finn and E.H. Franz. 1979. Perturbation theory and the subsidy-stress gradient. Bioscience 29:344-352.

Robertson, A.I., P.Y. Bernier and G. Heagney. 2001. The response of floodplain primary production to flood frequency and timing. Journal of Applied Ecology 38:126-136.

Taylor, J.R., M.A. Cardamone and W.J. Mitsch. 1990. Bottomland hardwood forests: their function and values. P. 14-34. In J.G. Gosselink, L.C. Lee and T.A. Muir (eds.) Ecological processes and cumulative impacts illustrated by bottomland hardwood wetland ecosystems. Lewis, Chelsea, MI, USA.

Tockner, K., F. Malard and J.V. Ward. 2000. An extension of the flood pulse concept. Hydrological Process 14:2861-2883.